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Methodology for Selection, Sequencing, and Deployment of Activities in a Capstone Design Course Using the Tidee Web-Based Assessment System

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METHODOLOGY FOR SELECTION, SEQUENCING, AND DEPLOYMENT OF ACTIVITIES IN A CAPSTONE DESIGN COURSE USING THE TIDEE WEB-BASED ASSESSMENT SYSTEM

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ABSTRACT
Assessment of design process, design products, team process, and professional practice are natural fits in an engineering capstone design course. In order for instructors and students to fully experience the value of capstone course assessment activities, the activities must not only be carefully developed but must also be deployed in an appropriate manner. Course designers must choose an optimal set of assignments based on local needs, while balancing time intensive design project activities with professional growth experiences. Instructors must facilitate the complete cycle of usage of a single assignment in order to ensure that the value is understood before and after completion of the assessment. This paper introduces guidelines for achieving effectiveness in selecting, timing, and sequencing assessment activities, preparing for activity deployment, and implementing a facilitation plan. Additionally this paper reports on the feedback from students and faculty using the system that highlights the importance of naturalistically integrating assessment.

1. INTRODUCTION
Since the capstone design course is the climax of undergraduate design education, it is often the context for much of the assessment performed in engineering degree programs [1]. A collection of assessments [2] was developed by the Transferable Integrated Design Engineering Education project team that focus on aspects of team and individual performance within the context of engineering design. These assessments, which provide valuable reflective opportunities [3, 4], were recently made more broadly accessible through a web-based implementation. The web implementation allows faculty to assign assessment exercises to individual students or to teams of students who then log in to a secure website to complete the assignment. Despite the careful development of assessment instruments and enabling aspects of the web interface, maximum benefit is not assured without careful selection and integration of assessment assignments into a capstone design course.

This paper provides guidelines for: (a) selecting assessment activities, (b) coordinating assessment activities with design project work, and (c) facilitating usage of each assessment. In developing these guidelines it was deemed critical that the assessment activities fit naturally into the student design process and are not viewed as extraneous data entry. To better understand the impact of using these guidelines, an analysis of student and faculty satisfaction was performed immediately following the use of the instruments. This analysis of student and faculty feedback illustrates that the seamless inclusion of assessment activities is critical to ensure that students are fully engaged in the activity and that the experience is highly valued.

2. TIDEE ASSESSMENT SYSTEM

Tomorrow's engineering practitioners must create practical design solutions responsive to rapidly changing user, business, technical, and societal needs. Their preparation requires clear professional and engineering design learning outcomes, crafted educational experiences, and responsive learner-focused feedback. The desired result is outstanding design engineers and engineering design solutions [5, 6].

The Transferable Integrated Design Engineering Education (TIDEE) consortium has created an integrated set of assessment tools for use in capstone engineering design courses and other team-based project environments [7]. TIDEE assessments target the following performance areas:

- **Professional Development**: Individuals document professional development in technical, interpersonal, and individual attributes important to their personal and project needs, professional behaviors, and ways of a reflective practitioner.
- **Teamwork**: Team member behaviors and team processes contribute to constructive relationships, joint achievements, individual contributions, and information management that synergistically yield high productivity.
- **Design Processes**: Designers reflectively use design tools and information throughout problem scoping, concept generation, and solution realization activities to co-develop problem understanding and a responsive design solution.
- **Solution Assets**: Designers deliver and effectively defend solutions that satisfy stakeholder needs for functionality, financial benefit, implementation feasibility, and impacts on society.

Each of the four areas of performance influences, and is influenced by, the other three areas. For example, professional development influences the validity and adequacy of solution requirements, affects quality of human resources available for team processes, and influences the quality of design solution assets. In turn, professional development gains from solution requirements and an increased customer-focus are driven by team processes toward greater social skill development, and gain feedback from solution assets regarding one's personal competence in design. In addition, solution assets drive design process to be practical [8], and they motivate team processes to be more productive. In turn, the solution assets gain from team processes a wholeness representing broad team inputs, and receive from solution requirements an understanding that makes solution assets responsive to stakeholder needs. These four areas of design performance interact synergistically to provide richness in engineering design performance that enhances development of both the learner and the solution [9].

The complete list of assessment assignments is found in Table 1 (page 3) and includes a brief description of each activity as well as factors used in scoring student performances. The complete set of assessment instruments can be viewed in detail on the TIDEE website [10]. In addition to the inherent benefits of assessment for learner development, assessment activities can be leveraged as part of an ABET accreditation effort. The mapping of assessment performance area to ABET outcome [11] addressed is shown in Table 2.

Table 2: Summary of Capstone Design Course Assessments

	ABET Criterion 3 Outcomes										
Performance Areas	3a. Apply knowledge of math, science, engineering	3b. Design and conduct experiments, and analyze, interpret data	3c. Design system, component, or process to meet needs under constraints	3d. Function on multidisciplinary teams	3e. Identify, formulate, solve engineering problems	3f. Understand professional & ethical responsibility	3g. Communicate effectively	3h. Understand impact of engineering solutions in global, economic, environmental, societal contexts	3i. Recognize need for and demonstrate ability to engage in lifelong learning	3j. Have knowledge of contemporary issues	3k. Able to use techniques, skills, modern tools of engineering practice
1. Professional Development	X				X	X			X		X
2. Teamwork				X			X				
3. Design Process			X				X	X		X	
4. Solution Assets		X	X				X	X			

3. REQUIREMENTS FOR DEPLOYMENT

Students and faculty experience added value in assessment activities when they are integrated in an assessment system that recognizes long-term professional needs of students as well as important course-level learning outcomes. This philosophy suggests two guiding principles for assessment instrument deployment.

1. All assessment activities should fit naturally into the design process and add value to the student, project, and client.
2. The assessment plan and workload must be sustainable for students as well as faculty over multiple semesters.

Table 1. Complete set of TIDEE assessment instruments

ASSIGNMENT INSTRUCTIONS (ABBREVIATED)	SCORING FACTORS
PROFESSIONAL DEVELOPMENT ASSESSMENTS	
GROWTH PLANNING: Rate importance and your level in professional attributes. Describe impacts of shortcomings, growth plans, and criteria for success.	○ Understanding of impacts; quality of plan; quality of achievement criteria
GROWTH PROGRESS: Describe steps taken, evidence of impacts achieved, next steps for achieving professional development.	○ Progress to-date, quality of evidence, quality of new steps planned
PROFESSIONAL PRACTICES: Rate importance and your performance for areas of professional and ethical responsibility; describe understanding and impact; describe opportunity for improvement and plan to improve performance.	○ Evidence of understanding and strong performance; understanding of opportunity and plan to achieve higher performance
◄ **GROWTH ACHIEVED**: Rate current importance and your level in professional attributes; check areas of greatest growth; describe gains, impacts and broader applicability of achieved professional development.	○ Scope of professional development gains, quality of impacts, understanding of broader application
TEAMWORK ASSESSMENTS	
TEAM CONTRACT: Define a consensus contract: team relationships, collective achievements, individual responsibilities, team communication, and leadership.	○ Contract clarity, comprehensiveness, specificity; potential for effectiveness and team development
TEAM MEMBER CITIZENSHIP: Rate members of team (including self) on contributions and effectiveness. For each member, identify a key strength and how it benefits the team, a desired improvement and steps to achieve this.	○ Understanding of strength; evidence of effective use; understanding of opportunity; quality of suggestions
TEAM PROCESSES: Rate importance and effectiveness of processes for: relationships, achievements, responsibilities, and information. Describe an effective process (with evidence); describe opportunity and plan to improve.	○ Understanding of effectiveness; evidence of success; understanding of opportunity; quality of plan
◄ **TEAMWORK ACHIEVED**: Rate team performance, importance of member contributions, level of member contributions; relative contributions of members; describe greatest teamwork strengths, impacts, and broader applicability.	○ Relative contributions of members; teamwork achievements, significance of impacts, and insight in applicability
DESIGN PROCESS ASSESSMENTS (ONE FOR EACH PHASE)	
PROBLEM SCOPING: **CONCEPT GENERATION**: **SOLUTION REALIZATION**: At mid-phase, define process components planned/used; assess process status; explain process strengths; propose process improvement	○ Evidence of process attributes that produce quality; ability to improve process for enhanced results
◄ **DESIGN REFLECTION**: Rate confidence in design work to-date; explain a strength; propose iteration to improve the design process	○ Substance and impact of strength; planned improvement and learning from reflection
SOLUTION ASSETS ASSESSMENTS	
DEFINED PROBLEM: Prepare a formal proposal submitted to stakeholders defining project requirements and requesting approval to proceed with conceptual design.	○ Quality of executive summary, stakeholder needs, and solution specifications for functionality, profitability, feasibility, and social impact ○ Quality of communication of the defined problem
SELECTED CONCEPT: Prepare a formal proposal submitted to project stakeholders justifying a proposed design concept and requesting approval to proceed to detail design.	○ Quality of executive summary and solution specs; concept potential for solution functionality, profitability, feasibility, and social impact ○ Quality of communication of the selected concept
◄ **PROPOSED SOLUTION**: Prepare a formal design report submitted to project stakeholders defending the developed design solution and requesting approval to proceed to implementation of the design.	○ Quality of executive summary and solution specs; proof of solution functionality, profitability, feasibility, and social impact ○ Quality of communication of the proposed solution

Note: ◄ denotes a summative assessment

The methodology described in this paper for integrating the TIDEE web-based assessment system into a capstone engineering course was developed with consideration for both the student and faculty experience. The methodology also addresses course level and activity level needs to ensure success for all stakeholders. These considerations in assessment system deployment are summarized in Table 3.

Table 3. Considerations in assessment system deployment.

	COURSE	ACTIVITY
Faculty Experience	• Faculty orientation on web technology and as well as activity design • ABET alignment • Assessment selection to reinforce course outcomes	• Set up activity for student use on the web • Introduce activity • Review student work • Debrief students
Student Experience	• Student orientation on web system as well as role of assessment in project learning • Relation of assessment activity to other course deliverables • Timing of assessment activity	• Receive instructions • Perform activity • Review feedback (from peers as well as faculty) • Make plans to act on feedback in upcoming project work

The methodology for using the TIDEE assessment system in a capstone course consists of three phases: 1) selecting, timing, and sequencing of activities, 2) preparation of assessors (faculty) as well as assessees (students) and 3) implementation of specific assessment activities, which includes orientation, data entry, scoring, and follow-up.

3.1 ACTIVITY SELECTION, TIMING, AND SEQUENCING

The TIDEE system features fifteen assessment activities from which to choose when selecting assessment activities for a capstone design course. Selecting too many activities or improperly aligning these activities with respect to the design project schedule can negatively impact the value and sustainability of assessment in the course. Tables 4 through 7 (see pages 4 and 5) contain a complete list of assessment activities and a recommended timing for their usage in a capstone project, which can be either a one or two semester effort. The tables are divided by their targeted performance area: professional development (Table 4), teamwork (Table 5), design process (Table 6), and solution assets (Table7). The timing information is a general recommendation of when each assessment assignment produces greatest value to the project and the design team. Rationale for the alignment of each assessment activity with capstone projects is also provided in Tables 4-7.

It is recommended that one-semester capstone design courses and new adopters of the assessment system use fewer assessment activities. A startup heuristic for entry-level users is to pick one team activity followed by two individual activities per semester. The first time students use the system they should expect to invest up to an hour generating a quality response. On their part, faculty can expect to allocate 10-15 minutes to skim, score, and respond to student submissions. With repeated experience with the TIDEE system, these times can be cut in half. Assessment assignments that are selected should be the ones that are perceived to have the highest leverage in terms of value to the student, instructor, client, and program. Good candidates for team assessments are: (a) problem scoping, (b) problem defined, (c) concept generation, and (d) concept selected. These occur during the front end of the capstone project where there is often fuzziness surrounding intermediate milestones. Good candidates for individual assessments are: (a) team member citizenship, (b) teamwork achieved, (c) professional practices, and (d) growth achieved. It is convenient to use these in the wake of major project milestones when individuals and teams are regrouping for the next phase of the course. In this regard, team member citizenship complements a mid-project design review; professional practice complements a mid-year design report; teamwork achieved complements completion of the detailed design; and growth achieved complements project completion. With more experience in administering, scoring, and debriefing assessment activities, instructors report that they are able to complete their review of individual and team submissions in 5-10 minutes and are comfortable using as many as five assessment activities per semester. Too many assignments can diminish the value perceived from the assessment by students and faculty and can produce time commitments that are not sustainable over time. An additional consideration for getting student buy in and ensuring sustainability is picking assignment due dates that do not conflict with major course deliverables.

Table 4. Description of deployment timing and rationale for professional development assessments.

PROFESSIONAL DEVELOPMENT ASSESSMENTS: INDIVIDUALS DOCUMENT PROFESSIONAL DEVELOPMENT IN TECHNICAL, INTERPERSONAL, AND INDIVIDUAL ATTRIBUTES IMPORTANT TO THEIR PERSONAL AND PROJECT NEEDS, PROFESSIONAL BEHAVIORS, AND WAYS OF A REFLECTIVE PRACTITIONER.			
ASSIGNMENT (ABBREVIATED)	**TIMING**	**RATIONALE FOR TIMING**	**TYPE OF SUBMISSION**
GROWTH PLANNING	○ Early in project – problem scoping	○ Inventory existing team capabilities ○ Identify need for specialized training in tools and techniques required for project success ○ Identify concrete opportunity for individual professional development within the context of the project	○ Individual
GROWTH PROGRESS	○ Mid project	○ Identify intermediate and terminal objectives for personal and professional development ○ Provide venue for scheduling and time management guidance surrounding long-term project goals, especially to individual team members.	○ Individual
PROFESSIONAL PRACTICES	○ After substantial concept generation work ○ Before detailed design is complete	○ Ensure that the team is aware of project impacts beyond the client and users. ○ Raise awareness of project requirements and constraints with respect to the public and society that were not initially identified. ○ Best used when students are sufficiently immersed to see broader impacts of previous decisions but not under pressure of fabrication, assembly, or testing.	○ Individual
GROWTH ACHIEVED	○ One week before end of project	○ Reflect on one's capstone experience against professional development goals previously identified for course. ○ Inventory lessons learned about self-directed learning, mentoring, and time management that can be taken forward into future projects.	○ Individual

Table 5. Description of deployment timing and rationale for teamwork assessments.

TEAMWORK ASSESSMENTS: TEAM MEMBER BEHAVIORS AND TEAM PROCESSES CONTRIBUTE TO CONSTRUCTIVE RELATIONSHIPS, JOINT ACHIEVEMENTS, INDIVIDUAL CONTRIBUTIONS, AND INFORMATION MANAGEMENT THAT SYNERGISTICALLY YIELD HIGH PRODUCTIVITY.			
ASSIGNMENT (ABBREVIATED)	**TIMING**	**RATIONALE FOR TIMING**	**TYPE OF SUBMISSION**
TEAM CONTRACT	○ After team assignment	○ Prompt discussion about important areas of team performance during team formation ○ Put individual and team commitments for product and process success in writing ○ Identify contentious issues requiring early instructor intervention	○ Team
TEAM MEMBER CITIZENSHIP	○ Mid-project	○ Rate performance of individual team members in different dimensions of teamwork ○ Reflect on one's contribution to project success ○ Recognize and discuss valuable contributions by individual members ○ Identify and describe fruitful areas for development/growth of individual members	○ Individual
TEAM PROCESSES	○ Mid-project	○ Provide forum for team discussion about team dynamics ○ Generate consensus about possible changes in team organization and management ○ Clarify possible communication issues with external stakeholders (client or instructor)	○ Individual or Team
TEAMWORK ACHIEVED	○ Several weeks before end of project	○ Reflect on one's design team experience separate from the design team product ○ Inventory lessons learned about teamwork, leadership, and communication that can be taken forward into future engineering projects.	○ Individual

Table 6. Description of deployment timing and rationale for design process assessments.

DESIGN PROCESS ASSESSMENTS: DESIGNERS REFLECTIVELY USE DESIGN TOOLS AND INFORMATION THROUGHOUT PROBLEM SCOPING, CONCEPT GENERATION, AND SOLUTION REALIZATION ACTIVITIES TO CO-DEVELOP PROBLEM UNDERSTANDING AND A RESPONSIVE DESIGN SOLUTION.			
ASSIGNMENT (ABBREVIATED)	**TIMING**	**RATIONALE FOR TIMING**	**TYPE OF SUBMISSION**
PROBLEM SCOPING	○ Two weeks after project start-up	○ Get students to think about their design process not just a design solution. ○ Serves as a concrete deliverable during fuzzy front end of the design process ○ Identify key areas where major project learning needs to occur.	○ Team
CONCEPT GENERATION	○ 5-6 weeks after project start-up	○ Monitor student progress in refining problem definition and problem decomposition ○ Ensure that teams are considering a sufficient set of ideas for possible inclusion in their design ○ Ensure selection process exists and is grounded in customer needs ○ Prompt teams to think about a product or process architecture that will embrace necessary subsystems	○ Team
SOLUTION REALIZATION	○ 2-3 weeks after mid-project design review or submission of mid-project design report	○ Verify that there is client approval regarding all aspects of the proposed design solution ○ Monitor progress in detailing the design, including component sizing ○ Prompt thinking about manufacturing plans and resources used for fabrication ○ Ensure that project is within budget ○ Ensure that project is on schedule	○ Team
DESIGN REFLECTION	○ At the end of a critical design phase	○ Inventory ways in which design was advanced ○ Discuss added value of particular design tools and methods to project outcomes ○ Recognize short-comings and suggest improvements to the design process or design product ○ Reflect on how well the team is using external resources (client, instructor, local experts, etc.)	○ Individual or Team

Table 7. Description of deployment timing and rationale for solution assets assessments.

SOLUTION ASSETS ASSESSMENTS: DESIGNERS DELIVER AND EFFECTIVELY DEFEND SOLUTIONS THAT SATISFY STAKEHOLDER NEEDS FOR FUNCTIONALITY, FINANCIAL BENEFIT, IMPLEMENTATION FEASIBILITY, AND IMPACTS ON SOCIETY.			
ASSIGNMENT (ABBREVIATED)	**TIMING**	**RATIONALE FOR TIMING**	**TYPE OF SUBMISSION**
DEFINED PROBLEM	○ 2-3 weeks after initial client contact	○ Provide early feedback to project stakeholders ○ Achieve team consensus on a problem statement ○ Inventory general requirements along with specific measures and tentative target specifications	○ Team
SELECTED CONCEPT	○ Alongside mid-project design review	○ Update problem definition in light of project learning ○ Summarize viable solution alternatives ○ Ensure that concepts selected meet stakeholder needs and have client approval ○ Outline likely sub-systems and interfaces ○ Surface key issues in the design that need to be addressed/decided	○ Team
PROPOSED SOLUTION	○ One month after mid-project design review	○ Trace design features to project specifications ○ Integrate sub-systems into product architecture ○ Identify components for purchase and manufacture ○ Report results of experimentation/testing ○ Evaluate design for next stage of development	○ Team

Figure 1 illustrates how TIDEE assessment activities are used at the University of Idaho in an interdisciplinary engineering capstone course with 80-100 students drawn from programs in agricultural engineering, computer engineering, electrical engineering, and mechanical engineering. This yearlong course features 10-12 industry sponsored projects, 2-3 competition projects, and 2-3 instrumentation projects in support of research grants. There are 3-7 students on each project team. The first semester schedule includes usage of the following TIDEE assessment activities: team contract, project selection, problem scoping, concept generation, and team member citizenship. These activities compliment the formation and development of design teams and the early stages of design. In the second semester, students transform concepts into finalized designs, fabricate, and test a prototype. The second semester schedule includes usage of the following TIDEE assessment activities: solution realization, professional practices, teamwork achieved, and growth achieved. Conscious attention was given to avoid clustering of assignments during mid-term exams and within two weeks of the end of each semester.

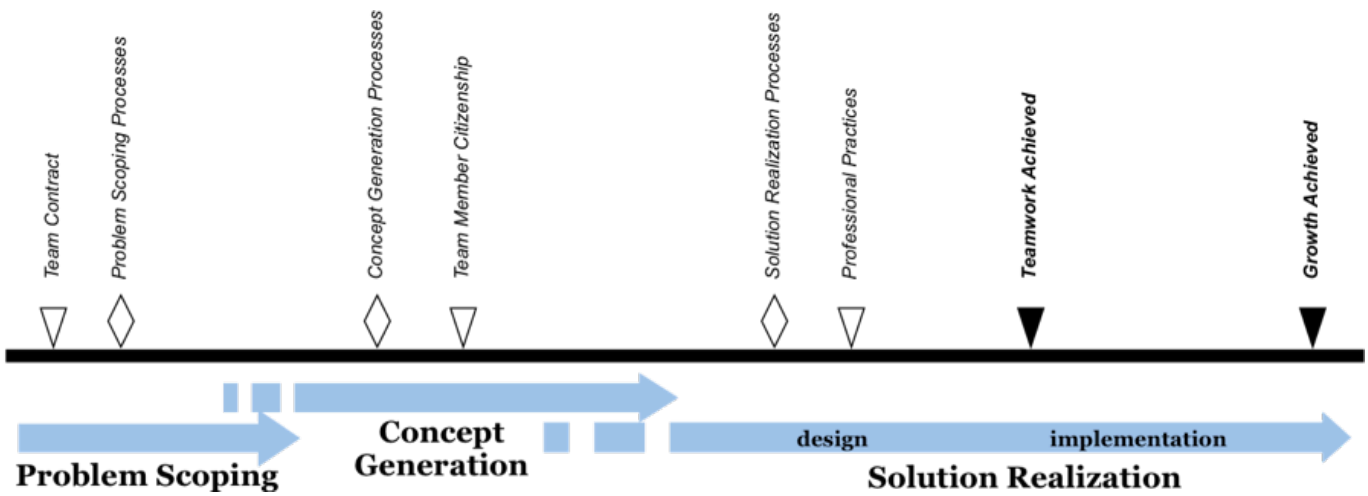

Figure 1. The mapping of assessment activities to capstone timeline at the University of Idaho.

There are several additional considerations for choosing and sequencing activities. Course designers should strive to balance the number of team and individual activities per semester. This creates opportunity for assessment and dialogue on a team-level as well as an individual-level. It is beneficial to use at least two team and two individual assessment activities within the capstone sequence to establish and reinforce protocols for providing data, scoring student work, reviewing faculty feedback, and debriefing about findings.

3.2 FACULTY AND STUDENT PREPARATION

The second piece of the methodology is the steps required to effectively facilitate the use of the specific assessment activities in conjunction with the web-based assessment system. In order to prepare faculty and students for using the TIDEE system, some orientation is required. Faculty should have a shared understanding of the value and facilitation plan for each assessment activity with other members of the instructional team. This is best performed by reviewing the scheduling, sequencing, and rationale for each instrument prior to the start of the semester. Also, instructors will want to examine options for assessment activities, discussing the questions asked of students and becoming familiar with the scoring rubrics that accompany each activity. To orient faculty to the assessment and rubric, a rater-training session is conducted which includes a review of the assessment exercise instructions to students, a review of the rubric criteria and Likert-scale anchors, and a general overview of the philosophy of the rating process. Following this, multiple exemplars are scored by the faculty to calibrate their scoring with the rubric. The web features of the assessment system require a minimal amount of training for faculty, however, a walk-through of the student web interface as well as the faculty interface is recommended for all instructors. To initiate use of the web system setup, faculty must create accounts for each student, identify the name of the team to which they belong, and identify relevant advisors/mentors for each team. For courses that involve multiple instructors, it is helpful to have one faculty member act as a course administrator that creates all assignments for students and faculty. Each student is provided with a username and password to log into the TIDEE system for completing assignments and reading feedback.

The way in which the TIDEE web-based assessments are presented to students in general class sessions will have an impact on their value. At the start of the course, it is recommended that the formative nature of these assessments be emphasized over their use in program assessment for ABET. It is beneficial to give examples how these have improved student learning and performance in past courses. It is also wise to give credit for thoughtful assignment completion in course grading. In this regard, it is worthwhile to remind students that grading of assessment activities is not related to the ratings and incidents they cite, but rather their authenticity and depth of reflective analysis. To prepare students for particular assessment activities, periodically allocate a small portion of time during general class sessions to remind students of due dates for upcoming assessment activities, preview assessment activities using the TIDEE web interface, allow time for questions about what is required in different sections of the activity, suggest time limits for data entry, and inform students when they can expect to see faculty feedback appear on-line.

3.3 IMPLEMENTATION CYCLE

Each assessment activity requires several interactions between students and faculty to ensure that the maximum value is achieved. The implementation cycle (Figure 2) begins with the creation of a web assignment by the lead course instructor. Creating the assignment includes indicating which students are to receive the assignment, the due date of the assignment, and the due date of the instructor feedback. Instructors should review the assignment in a general class session one to two weeks in advance of the due date.

Students complete the assignments outside of class as individuals or as a team if called for by the activity. Ideally, activities should require 15 to 30 minutes for students to complete. This amount of time is sufficient for students to provide thoughtful, value-added responses while not overly burdening them with data entry. Similarly, the amount of time required by the faculty to score and respond to student work should not dissuade future use. Using the scoring rubrics and prompted comment boxes, faculty can provide high quality feedback in 5 to 10 minutes per student. If the faculty member has 25 students that report to him/her, faculty feedback can be generated in 2-4 hours, not an unreasonable of amount of time for grading in other courses. Additional time savings are implicit in the web automation that is provided by the TIDEE system. No user time is required for activities such as team member citizenship, which processes statistics from all team members about all other members.

The value of the activity is greatly enhanced when students log back into the system to read feedback from the instructor (and sometimes other students). Through their feedback, faculty can demonstrate empathy with respect to project challenges, set the stage for an individual or team discussion about critical issues, provide guidance on project management, and plan intervention with clients when this is necessary.

4. STUDENT AND FACULTY FEEDBACK

Quantitative analysis of faculty and student survey data provides an empirical example reflecting the importance of the three components for effective implementation discussed above. These data were collected via surveys paired with the TIDEE team member citizenship assessment instrument used at the University of Idaho over an academic year by 81 students belonging to 12 project teams that were each supervised by one of four instructors. Each student team responded to items eliciting perceived estimates of the accuracy of instructor feedback, personal value derived from using the instrument, added-value to project work, and the amount of time it took them to complete the assessment. In addition, faculty completed a similar survey for each team they evaluated. Faculty instruments identified the assessment's effectiveness by team for identifying struggling teams, identifying teams which excelled, guiding student remediation efforts, providing accurate representations of

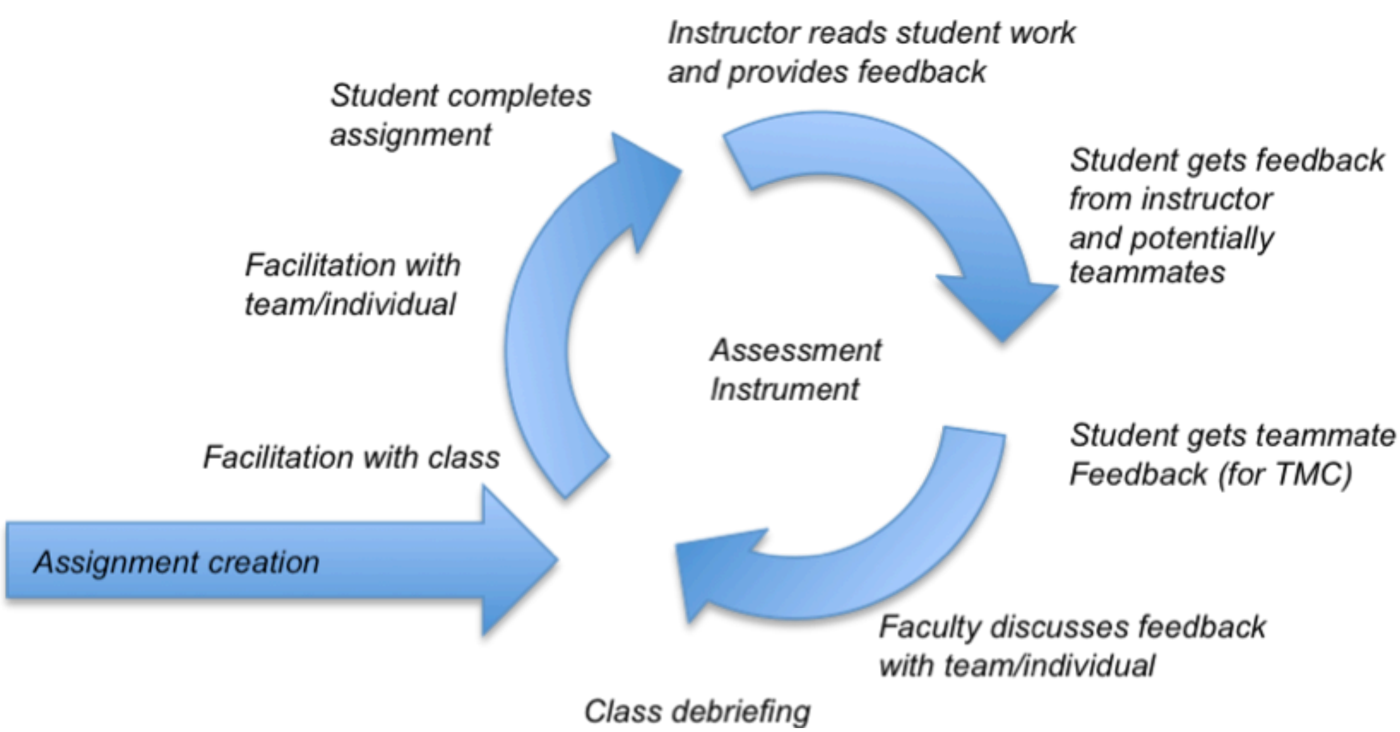

Figure 2. Implementation cycle for a specific assessment activity.

student work, and the amount of time necessary to complete the assessment. Response items were based on a 5-point Likert scale with the following anchor labels: (5) very accurate/very valuable, (4) mostly accurate/generally valuable, (3) somewhat accurate/somewhat valuable, (2) mostly inaccurate/little value, and (1) very inaccurate/no value. Time was estimated in terms of minutes spent on the completion or grading of the assessment for students and instructors, respectively.

Figures 3 through 5 provide an overview of descriptive data for student responses. Due to the small number of instructors, chi-square statistics could not be computed, but it is important to note that a substantial number of student participants and a majority of instructors rated the team member citizenship assessment as mostly accurate/generally valuable to very accurate/very valuable in each category. Specifically, out of 54 total respondents 41 students perceived instructor feedback as very accurate or mostly accurate (Figure 3), 26 students found the exercise to be personally very valuable or generally valuable (Figure 4), and 26 students found the exercise to be very valuable or generally valuable to the team (Figure 5). All faculty respondents rated the exercise as being at least generally valuable in providing feedback and generally accurate as a representation of student ability. In addition students reported a completion time corresponding to about 5-10 minutes of work per team member in the group (including themselves) and approximately 5 minutes to complete the first section of the exercise. Faculty reported approximately 5 minutes of effort to read each student response and 5-10 minutes to create feedback.

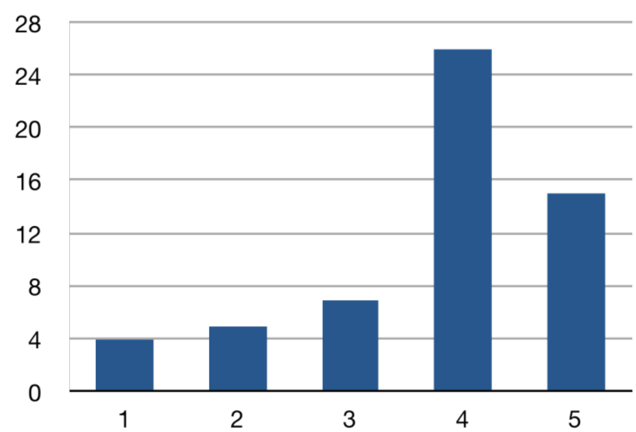

Figure 3. Student perception of assignment accuracy.

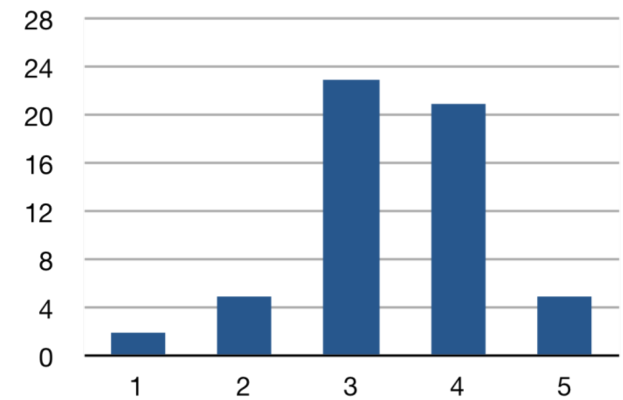

Figure 4. Student perception of personal value derived from the assignment.

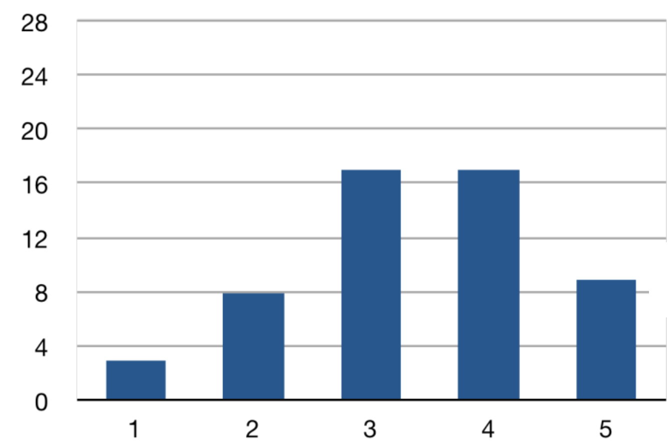

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Figure 5. Student perception of team value derived from the assignment.

Student quotes provide insights about the personal value derived from the assessment as well as the practicality of the assessment. While the majority of student quotes were positive, a balanced selection of quotes is included.

> *"I'm glad we did this assignment. It really helped me see some things about my own behavior that I did not notice before."*

> *"The first section* (rating the importance of different aspects of teamwork) *provided me with little information. All the other information was useful."*

> *"Despite the long arduous format, I felt it was very valuable."*

> *"I feel this assessment was too short. Though it did address significant topics, it should be written to touch on specific questions asked in the initial team contract."*

5. CONCLUSIONS

Capstone engineering design courses are an invaluable part of every engineering baccalaureate degree program [12, 13]. They play a critical role in providing opportunities for students to develop professional skills needed for innovative, responsible practice in a global environment. Additionally, engineering capstone design courses provide vital assessment data for accreditation of degree programs.

The complete set of TIDEE assessment instruments for capstone engineering design courses address four major areas of performance in capstone engineering design—professional development, teamwork, design processes, and solution assets. Each exercise is accompanied by a scoring rubric through which instructors provide feedback. Web interfaces for these assessments have expanded the potential for sustainable use by faculty and by students alike, but maximum value can only be achieved when the students and faculty are properly oriented with the instruments and the assignments. To ensure proper facilitation and a shared understanding of the value of assessment activities, guidelines for selecting, sequencing, and aligning assignments with design project activities were presented. Student and faculty use of the web-based assessment system was also enhanced through carefully planned orientation activities and attention to each of the steps in the implementation cycle.

Surveys completed by students and faculty point towards the criticality of ensuring naturalistic application of each instrument in order to avoid student and faculty disengagement. If students or faculty sense that assessment assignments are extraneous data entry activities, their perception and success at using the instrument is negatively affected. Ideally, web-based assessment activities in capstone design should focus on adding direct value to the design activities themselves in a way that is apparent to faculty and students.

ACKNOWLEDGEMENT

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6. REFERENCE

[1] McKenzie, L.J., M.S. Trevisan, D.C. Davis, and S.W. Beyerlein. (2004). "Capstone design courses and assessment: A national survey." Proceedings of American Society for Engineering Education Annual Conference, Salt Lake City, UT.

[2] Davis, D.C., S.W. Beyerlein, and I.T. Davis. (2005). Deriving Design Learning Outcomes from a Professional Profile. International Journal of Engineering Education.

[3] Adams, R.S., J. Turns, and C.J. Atman. (2003). Educating Effective Engineering Designers: The Role of Reflective Practice. *Design Studies* 24: 275-294. Elsevier Science Ltd.

[4] Turns, Jennifer. (1997). "Learning Essays and the Reflective Learner: Supporting Assessment in Engineering Design Education." Proceedings of the Frontiers in Education Conference

[5] Boeing Company. (2008) Desired attributes of an engineer. [List of attributes Boeing desires in graduating engineers] Available from: http://www.boeing.com/educationrelations/attributes.html

[6] National Academy of Engineering, (2004). *The Engineer of 2020: Visions of Engineering in the New Century*. The National Academies Press, Washington, DC.

[7] Beyerlein, S., Davis, D., Trevisan, M., Thompson, P., and Harrison, Kunle, (2006). Assessment Framework for Capstone Design Courses, Proceedings of American Society for Engineering Education Annual Conference, Chicago, IL.

[8] Gerlick, et al., (2008) Assessment Structure and Methodology for Design Processes and Products in Engineering Design Courses. Proceedings of American Society for Engineering Education Annual Conference, Pittsburgh, PA.

[9] Davis, D., Trevisan, M., Beyerlein, S., Thompson, P., and Harrison, Kunle, (2006). A Conceptual Model for Capstone Engineering Design Performance and Assessment, Proceedings of American Society for Engineering Education Annual Conference, Chicago, IL.

[10] TIDEE. (cited 2009) Compete set of assessment instruments. http://www.tidee.org

[11] ABET. (cited 2008) Criteria for accrediting engineering programs. Available from http://www.abet.org

[12] Todd, R., Magleby, S., Sorensen, C., Swan, B., and Anthony, D. (1995). A survey of capstone engineering courses in North America, *Journal of Engineering Education*, **84**(2), pp. 165-174.

[13] Howe, S. and Wilbarger, J. (2006). 2005 National Survey of Engineering Capstone Design Courses, Proceedings of the American Society for Engineering Education Annual Conference, Chicago, IL